Beaked Whale Group Deep Dive Behavior from Passive Acoustic Monitoring

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LONG-TERM GOALS

Although the causal link between sonar and stranding has not been described explicitly, beaked whales are one of the cetacean taxa more sensitive to use of Navy sonar (Moretti *et al*., 2014; Tyack *et al*., 2011). Despite their vulnerability, Blainville's beaked whale, *Mesoplodon densirostris* (*Md*), are routinely detected year-round on the AUTEC range, coincident with routine use of Navy sonar. This has led to the suggestion that perhaps whales can become habituated to sonar or at least do not respond in the same way as naïve animals (Schorr *et al*., 2014). Perhaps whales choose to stay in areas of frequent sonar use because the advantages of greater foraging opportunities outperform the disadvantages of sonar exposure. This suggestion makes AUTEC an excellent laboratory to understand not only fundamental aspects of their biology and ecology, but also how and why these whales might be impacted by the use of sonar.

We propose to address this question by creating a new post-processing detection, classification and localization method capable of utilizing passive acoustic data from the hydrophone array at AUTEC to track individual clicking beaked whales within group deep dives, and by creating a model relating acoustic footprint statistics (e.g., click detection counts, number of hydrophones detected on, etc.) on hydrophones to group size and parameterize it using surface visual observations. The model will expand upon current automatic group assignment software in Matlab using detection archives from the Marine Mammal Monitoring on Navy Ranges (M3R) system (Jarvis *et al*., 2014), and will also enable development of a real-time algorithm to estimate and display group size information for support of routine density estimation (e.g., Marques *et al*., 2009 and Moretti *et al*., 2010) and other field experiments. These results will be used to create a statistical model of beaked whale group deep dive behavior.

OBJECTIVES

While much information is known about individual beaked whale behavior at depth from Digital acoustic recording Tags (DTags) (Johnson and Tyack, 2003; Johnson *et al*., 2004; Madsen *et al*., 2013; Shaffer *et al*., 2013), little is known about beaked whale group dive behavior at depth. This lack of information makes it difficult to interpret the results of single animal exposures to anthropogenic noise, and their impact on long term foraging success and population health. The objective of this study is to provide novel information on beaked whale group foraging dive behavior using Passive Acoustic Monitoring (PAM) at the Atlantic Undersea Test and Evaluation Center (AUTEC). Specific objectives include:

1. Create a new detection, classification and localization method to track individual clicking beaked whales within group deep dives using passive acoustic data from the hydrophone array at AUTEC.
2. Create a model relating acoustic footprint statistics (e.g., click detection counts, number of hydrophones detected, etc.) on hydrophones to group size and parameterize it using surface visual observations.
3. Create a statistical model of beaked whale group deep dive behavior using the results of (1) and (2).

APPROACH

We propose to use the following three-tiered study approach:

1. Create a new post-processing detection, classification and localization method capable of utilizing passive acoustic data from the hydrophone array at AUTEC to track individual clicking beaked whales within group deep dives. By tracking individual whales within a group foraging dive we will be able to evaluate group foraging strategy at depth including: prey capture attempts, spatial relationships among conspecifics, independent or cooperative prey hunting, and foraging strategy. Preliminary work indicates such tracking is feasible.
2. Create a model relating acoustic footprint statistics (e.g., click detection counts, number of hydrophones detected on, etc.) on hydrophones to group size and parameterize it using surface visual observations. The model will expand upon current automatic group assignment software in Matlab using detection archives from the Marine Mammal Monitoring on Navy Ranges (M3R) system (Jarvis *et al*., 2014). The statistical model will also enable development of a real-time algorithm to estimate and display group size information for support of routine density estimation (e.g., Marques *et al*., 2009 and Moretti *et al*., 2010) and other field experiments.
3. Create a statistical model of beaked whale group deep dive behavior using the results of (1) and (2). The model will include behavioral dynamics of individuals within the group, group foraging strategy, and reaction to surface ship sonar (e.g., Moretti *et al*., 2014).

WORK COMPLETED

Field work for the first field season is scheduled from October 18th to October 23rd, 2015 to add additional visually verified groups by targeting the Whiskey 1 & 2 arrays for field study. During the

second and third year of the program, new field data collected by the Bahamas Marine Mammal Research Organisation during the previous year will be added to the queue for analysis.

RESULTS

Not yet available.

IMPACT/APPLICATIONS

Detailed information on beaked whale within-group dive behavior will fulfill a critical data gap in the Navy's behavioral response studies and noise impact models, defining baseline behavior and allowing better understanding of "biologically significant" behavioral changes. This information will assist Navy training ranges in addressing environmental compliance requirements that threaten operational availability (USW-TOC-03) and access of Navy warfighters to undersea warfare training that improves their capability to exploit adversary undersea assets (USW-AA-06).

RELATED PROJECTS

None

REFERENCES

Jarvis, S. M., Morrissey, R. P., Moretti, D. J., DiMarzio, N. A., & Shaffer, J. A. (2014). Marine Mammal Monitoring on Navy Ranges (M3R): A Toolset for Automated Detection, Localization, and Monitoring of Marine Mammals in Open Ocean Environments. Marine Technology Society Journal, 48(1), 5-20.

Johnson, M., Madsen, P. T., Zimmer, W. M. X., De Soto, N. A., & Tyack, P. L. (2006). Foraging Blainville's beaked whales (Mesoplodon densirostris) produce distinct click types matched to different phases of echolocation. Journal of Experimental Biology, 209(24), 5038-5050.

Langrock, R., Marques, T. A., Baird, R. W., & Thomas, L. (2014). Modeling the diving behavior of whales: a latent-variable approach with feedback and semi-Markovian components. Journal of Agricultural, Biological, and Environmental Statistics, 19(1), 82-100.

Madsen, P. T., de Soto, N. A., Arranz, P., & Johnson, M. (2013). Echolocation in Blainville's beaked whales (Mesoplodon densirostris). *Journal of Comparative Physiology A*, 199(6), 451-469.

Marques, T. A., Thomas, L., Ward, J., DiMarzio, N., & Tyack, P. L. (2009). Estimating cetacean population density using fixed passive acoustic sensors: An example with Blainville's beaked whales. The Journal of the Acoustical Society of America, 125(4), 1982-1994.

Moretti, D., Thomas, L., Marques, T., Harwood, J., Dilley, A., Neales, B., & Morrissey, R. (2014). A Risk Function for Behavioral Disruption of Blainville's Beaked Whales (*Mesoplodon densirostris*) from Mid-Frequency Active Sonar. PloS one, 9(1), e85064.

Schorr, G. S., Falcone, E. A., Moretti, D. J., & Andrews, R. D. (2014). First long-term behavioral records from Cuvier's beaked whales (Ziphius cavirostris) reveal record-breaking dives. PloS one, 9(3), e92633.

Shaffer, J. W., Moretti, D., Jarvis, S., Tyack, P., & Johnson, M. (2013). Effective beam pattern of the Blainville's beaked whale (*Mesoplodon densirostris*) and implications for passive acoustic monitoring. The Journal of the Acoustical Society of America, 133(3), 1770-1784.

Tyack, P. L., Zimmer, W. M., Moretti, D., Southall, B. L., Claridge, D. E., Durban, J. W., ... & Boyd, I. L. (2011). Beaked whales respond to simulated and actual navy sonar. PLoS One, 6(3), e17009.

Ward, J., Jarvis, S., Moretti, D., Morrissey, R., DiMarzio, N., Johnson, M., & Marques, T. (2011). Beaked whale (*Mesoplodon densirostris*) passive acoustic detection in increasing ambient noise. The Journal of the Acoustical Society of America, 129(2), 662-669.